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Lemenkova P.A.

SUSTAINABILITY OF THE MARINE ENVIRONMENT TOWARDS THE ANTHROPOGENIC IMPACTS IN THE ECOSYSTEM OF THE BARENTS SEA

Czech Republic
PhD Student of the Ecological Faculty, Karl University, Prague, Czech Republic
pauline.lemenkova@gmail.com

Abstract: Among all Arctic seas, the Barents Sea is characterized by its unique environment and high level of the biodiversity. At the same time the Gulf Stream waters transport large amounts of pollutants in the Barents Sea bringing various contaminants and substances from the North Sea. Nowadays, there are in Timan Pechora-Carboniferous basin located in the Barents Sea with 76 oil and gas subsidies, which store a quarter of all Russian oil. The ecological stress on the Barents environment is extremely high. As a result of contamination, the current state of the Arctic environment in the unique area of the Barents Sea may become threatening provided human impact remains at the same level. This article demonstrates the problem of nature resistance towards human impact. It shows negative human impact on the environment. Current geo-ecological situation in the Barents Sea as a unique hydrodynamic system is analyzed. The consideration is given both to the level of negative human impacts on the marine ecosystem as well as to the resistance of nature, i.e. the ability to deal with environmental stress, multiplied by their geographical location in the Arctic climate.
Key Words: marine ecosystems, Barents Sea, marine environment, water pollution, ecological sustainability

Analyzing geoecological situation of the marine basin, particularly such complex as Barents Sea, it is necessary to understand it as a unique hydrodynamic system with specific interaction of meteorological, biochemical and hydrological processes, hierarchical structures and subcomponents and indissoluble connexion with the coastal territory [11, p.38].

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Geographic factors determining natural capability of the ecosystem to resist towards the anthropogenic impacts should be briefly discussed. Geographical features of any water basin is the primary factor which determines the ecological situation of the territory. Even the same anthropogenic pressing under the radical different conditions (e.g., in tropical and polar regions) and in various ecosystems could cause quite different effects [22, p.87]. The geoecological analysis of the marine ecosystems in the Barents Sea presented in this paper is based on the thourough analysis of the information on its geographic and environmental conditions. The following important natural features are analyzed: types of geologic ground, geomorphological structures of the region, e.g. types of the seafloor bottom, coastal shelf area, morphological structures, morphologically similar zones of water areas, borders of the criolithozone, topography of the coast, temperatures of water.

Various natural geographic factors regulate the distribution of the contaminants within the ocean basin, accelerating or breaking the behaviour of chemical processes. That is why an additional background information containing natural geographic components of marine ecosystems is used. Bathymetry plays important role in the environment of the Barents Sea. It controls the status of the ecosystem, as its shelf continues much further than all other seas in Arctic basin [8, p.121]. Having numerous hollows and depressions, steep slopes and submarine mountains, the seafloor of the Barents Sea has complicated bathymetry. In such a way, it creates contamination transfers and places for their accumulation in its deepest parts and submarine canyons. The deepest points and the most intersected seafloor bottom with steeps are notable in the western part of the sea. On the contrary, shallow depths (<50 m) are mostly located on the south in littoral zones of the Pechora Sea and eastern parts of the Barents [12, p.247]. According to this, they represent the most important geomorphological features of the Barents Sea, its coastal

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territories and linear geomorphological characteristics (e.g. morphological structures and geomorphological similar areas).

The hydrological characteristics of the Barents Sea have different features compared to other Arctic seas. Namely, intense income of warm Atlantic waters coming from the Gulf Stream through the western part of the basin via the Norway Sea [24, p.110]. The main direction of the current systems in the Barents Sea can trigger serious ecological problems. Being the most important current of the Barents Sea determining its hydrological regime, it is formed by the Nordcap current, carrying warm and salty water directly from the Atlantic Ocean. That means all the polluted waters of Western Europe may flow directly into the Barents Sea, i.e. the activities of the oil drilling in the Norway Sea and the Sellafield which caused the increase of a-HCH concentrations in the Barents Sea.

Besides a branched system of the warm Nordcap current, the Barents Sea has exchange of waters with the open Arctic Ocean, Kara and White Seas waters which provide the additional inflow of the pollutants. Great bulk of pesticides and polychlorinated biphenyls (PCB's) come into the sea by river flow and land drainage and also by sea currents (e.g. Gulf Stream into the Barents Sea). Understanding how important the oceanological characteristics are for an ecosystem (such as temperature, salinity), one can better realise the behaviour of the contaminants in the waters [23, pp.12-15].

Geological types of the bottom sediments and lithological structures are important features for the ecology of the sea, because the lithological compositions of the ground directly influences the absorbing capabilities of its bottom sediments [13, pp.207-226]. Hence, the processes of absorption and accumulation of pollutants will be much more intensive on the surfaces with prevailing thin-grained structure (e.g. silty sediments). The pollutants themselves will remain in the ground much longer and will be washed out slower than those from the coarse-grained ground [9, p.58]. Accordingly, for instance, shelf

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parts are much more favourable for the absorption of different contaminants. The distribution of the different types of the bottom sediments correlates with the distribution of ^{137}Cs and PCB's contaminations since these water pollutants gather in bottom sediments and are better absorbed by silty sediments than by those with coarse-grained structure (pebble, gravel). In these ones, the concentration of the pollutants is much lesser.

The glacial situation has fundamental importance for the ecology of the Barents Sea. The ice sheet has impact on the formation of the submarine coast slope and its morphological structure. By weakening the intensity of the waving and consequently, their morphological forming forces it creates forming flat slope of the submarine slope where fine-grained silty sediments absorb more substances as compared to the sand. It should be also noted that such natural features as permafrost, excess watering, low temperatures and polar criolithozone reduce tempo of the biochemical processes, i.e. altogether they create favourable conditions for the contaminating of the sea. In that way it leads to the destruction of the ecosystems.

Water solubility of oil and other petroleum products linearly depends on the temperature of water and the distribution of criolythozone. That is why negative biological effects of oil contamination have most negative effect in the polar ecosystems where low temperatures of air and water reduce the speed of biochemical processes even during the summer period. The oil which gets under the ice cover, accumulates in the depressions of its under-surface and is being absorbed by the ice. During ice melting these oil spots are poured out directly into the water. Hence, the ice cover plays important role for the functioning of ecosystems. The borders of complete ice covering in March and September reflect temperature conditions, isotherms of upper water layer in the summer months and possibility of the oil contamination [15, pp.103-110]. Melt of land glaciers polluted by the precipitations or radioactive elements leads to the additional income of pollutants into the sea. Geoecological zoning of the

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Barents Sea is made mentioned above information using main principles of complex geoecological mapping [17, p.73].

The GIS offers tools for the integration of different spatial data and performing complex geographical analysis and research. For mapping a series of ecological maps of the Barents Sea the ArcView was used. This GIS enables to make a dynamic connection between the attribute data containing various characteristics of objects (e.g. the number of concentrations of contaminants) and spatial characteristics of objects [10, p.392]. The standard ArcView-format shapefile as thematic layer was utilized to keep spatial data and attributes.

Various thematic maps and data from different sources containing geographic aspects and ecological factors with impact on the environmental conditions of the Barents Sea were analysed (Fig.1). This enables to create GIS project for mapping using data on the geographic natural specifics of the Barents Sea. All thematic information concerning the environment of the Barents Sea available in the AWI archives were analysed. These included marine geology, geomorphology, climate, hydrological conditions, biological resources, soil of coastal areas, ecological data on emissions and concentrations of contaminants, glacial and ice conditions. All data were visualized as tables.

Furthermore, the GIS ArcView was used to analyse topological thematic layers where all thematic information was stored: the bathymetry of the Barents Sea, coastal lines, glacial areas, different types of bottom sediments, geomorphological characteristics of the seafloor etc. using principles of GIS application for the environmental studies [1, p.83], [2, p.259], [5, p.289], [14, p.45]. The database has been created as a dbf-format file in the ArcViewCatalogue, containing values of the contamination concentrations and their placement in sea basin: ^{137}Cs, PCB's, pesticides as a- and b-HCH, petroleum hydrocarbons, heavy metals (Ni, Cu, Zn, Cd etc.) for different points of the Barents Sea where the water samples were taken.

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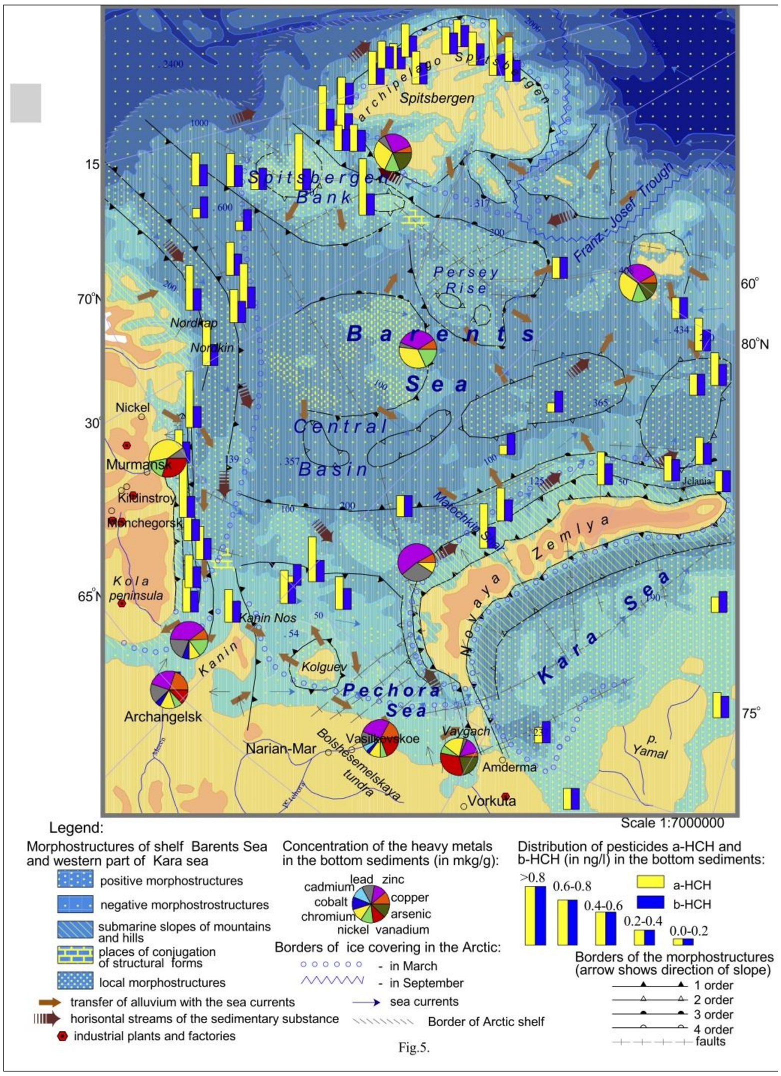

Fig.1. Distribution of the heavy metals within the Barents Sea.

Thematic maps showing environmental situation in the Barents Sea were created (Fig.1, Fig.2) on the basis of the

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available data and typical cartographic tasks: editing, analysing, combining layers with thematic data, creation and editing of legends and attribute tables, charts, and finally, visualization of layouts. The maps were drawn using ArcView Map on the basis of manuals for GIS mapping in marine and environmental cartography [3, p.62], [6, p.38]. The mapping process comprehended the creation of several thematic layers as 52 shape-files. In this files geographic features of the Barents Sea's environment were visualized, also ecological information of concentration and sources of contaminants, possible ways of their transportation and the accumulation in the bottom of the sea. The layers containing information on geological structure of the ground were compared. The values of different concentrations of the pollutants were analysed. The geological types of the bottom sediments were monitored as the absorption and accumulation of pollutants is much more intensive on the surfaces with dominating silty sediments. At the same time, the pollutants themselves will remain in the ground longer and will be washed out slowly than those on the coarse-grained ground. The regions with dominating fine-grained type of sediments are much more vulnerable, prone to the ecological pressure and destruction of the environment. The areas of the criolithozone expansion are considered for the ecological analysis, since low temperatures have direct impact on the speed and tempo of biochemical reactions.

Geoecological zoning is realized on the basis of the analysis of all available information containing ecological data (e.g. distribution of the contaminants within the sea basin) and geographic background (Fig.2). The shp-files were overlapped, representing environmental situation of the sea as a result of anthropogenic activities and natural geographic forces [19, p.32]. Thus, the geoecological analysis is a summarized assessment of the environmental conditions of the marine ecosystem which is detected nowadays. The identification of the regions was done based on the analysis of the impacts of the separate contaminants

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taking into account geographical features of territories by overlapping GIS layers [7, p.205].

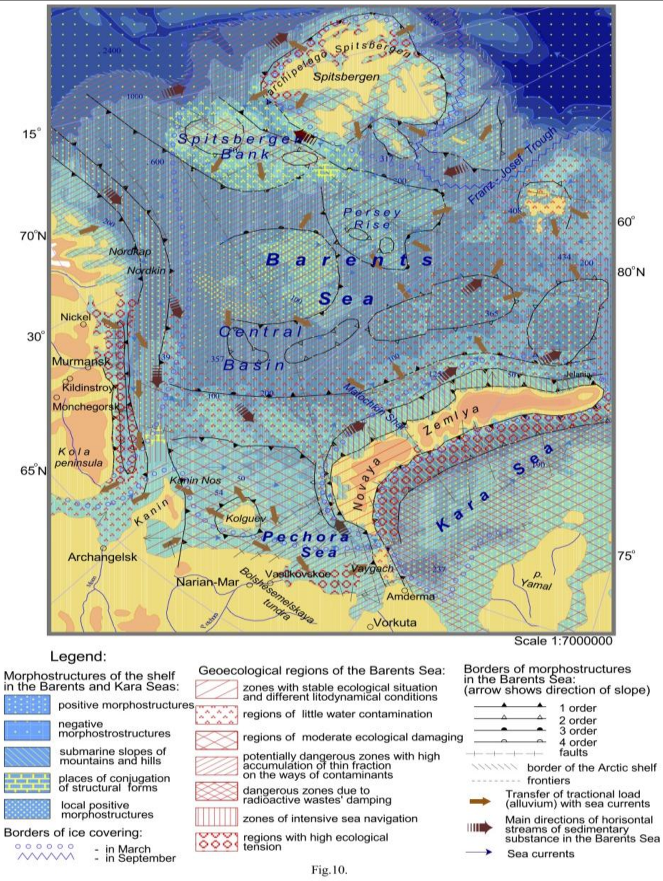

Fig.2. Geoecological zonation of the Barents Sea

In such a way, it influences the ecological status of the marine environment as a whole. Moreover, the coastal and littoral

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regions are separated from open sea areas due to the high concentration of biological productivity and resources which make them more vulnerable compared to the open sea areas.

Final geoecological map (Fig.2) was created using main recommendations for the GIS mapping and environmental zoning [16, p.79], [18, p.68], [20, p.55] as well as examples of the ecological zoning or the priority areas in the Barents Sea. A drawing of the border lines was done based on the geomorphological zoning of the basin [4, p.211], [21, p.35], as similar regions indicate main morphological structures of the region, that appear to be basic areas with equal status. Other differences of the ecological stability or non-stability can be investigated using the same principle, as dominating process of accumulation of the contaminated sediments is directly depending on the seafloor.

Located within polar conditions, the coastal shelf zones have a number of features and characteristics. These include for instance the intensity of ice building process, diminished wave process, thermal abrasion, thermal denudation, solifluction and frosty destruction of coasts. The thermo-abrasive coasts are widespread along the shore of the Arctic. In case of their destruction it becomes a region with one of the most important sources of transport of the sedimentary substances. At least 50% of the Arctic coasts are prone to the abrasion. The abrasion leads to the enormous losses of coasts: environmentally valuable coastal lands are being lost, near-coastal industrial buildings are being destructed, thereby bringing additional input of the contaminants into waters. Denudational coasts are formed by the frozen destruction processes which cause supplementary import of sediments into the basin.

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